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ELECTRON BEAM CONTROLLED FRAGMENTATION OF A 5"/38 PROJECTILE (U)

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FOREWORD

(U) The study of electron beam embrittlement techniques for controlling fragmentation of munitions was conducted in the Munitions Division of the Surface Warfare Department and funded under ORDTASK 841002/090-1/UF 7353502 and 35D001/090-1/UF 50353506. This report was reviewed by D. D. Abernathy, Advanced Development Manager, Munitions Division and C. A. Cooper, Head, Munitions Division.

Approved for Release

C. W. BERNARD
Head, Surface Warfare Department

ABSTRACT

(U) The design, fabrication and testing of a 5"/38 controlled fragmentation projectile is described in this report. An electron beam welding machine was used to score the outside wall of a 5"/38 MARK 52 projectile to control fragmentation. This projectile was launched from a five-inch gun, sawdust recovered intact, and fragmented in a sawdust recovery bin. Test results indicate that excellent fragmentation control was obtained.

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INTRODUCTION

(U) Conventional projectiles, upon explosion, produce a wide range of fragment weights and velocities. Improved lethality can be achieved by designing the projectile to fragment in a predetermined pattern. This concept also applies to bombs and other fragmenting munitions. The concept of controlling fragmentation through electron beam embrittlement was conceived and developed by personnel of the Naval Weapons Laboratory. This technique appears to be one of the most promising methods of achieving controlled fragmentation.

(U) Electron beam embrittlement is accomplished by scoring the outside wall of the munition with an electron beam welding machine. The welder directs a high energy beam of electrons onto the wall of the munition heat treating a very localized area. Upon detonation of the explosive loaded munition, the walls break up into fragments of the sizes and shapes predetermined by the scoring pattern used.

(C) Some of the early electron beam experiments reported in reference (a) used rectangular shaped fragments. The degree of fragmentation control with rectangular fragments was not optimum, but a very interesting shear flow fracture was observed. These data and information on internal notching fragmentation (reference (b)) led to the evolution of a diamond shaped scoring pattern which was very successful in controlling fragmentation of five-inch diameter thin-walled cylinders. Figure 1 shows ultra high speed photographs of the early stages of fragmentation. Figure 2 shows recovered fragments. Data from these early experiments have been used to assist in the design of the 5"/38 controlled fragmentation projectile discussed in this report.

DESCRIPTION OF HARDWARE

(C) A 5"/38 MARK 52 projectile was electron beam scored with the diamond shaped pattern shown in Figure 3. The electron beam scoring region began approximately ¼" in front of the copper rotating band and extended forward about 10 inches. The 60° diamond pattern was spaced so that there were twenty diamond fragments in each circumferential row. The entire welded region contained a total of

280 diamond shaped fragments. The scoring pattern was designed to produce fragments weighing approximately 500 grains; however, it was necessary to use smaller diamonds in the ogive region because of the curvature of the projectile.

(C) A cross-section of the 5"/38 projectile is presented in Figure 4. Note the uniformity of the heat affected zones. The penetration depth is 0.375" or approximately 75% of the projectile wall thickness.

(U) The electron beam welding machine parameters used for this scoring operation were as follows:

a. weld speed = 45 inches/min.
b. machine voltage = 35 kilo-volts
c. machine amperage = 145 milli-amps

RECOVERY TEST

(C) The scored 5"/38 recovery projectile contained an inert load and was equipped with a 3½" diameter flat nose plug. The firing weight of the round was 55.18 pounds. The projectile was fired from a 5"/54 gun at a muzzle velocity of 2285 ft/sec into a sawdust filled box car. An inflight view of the projectile is presented in Figure 5. The projectile successfully withstood the acceleration of gun launching (approximately 7800 g's) and the rotational forces associated with a spin rate of 223 rps. The projectile, as recovered from the sawdust filled box cars, is shown in Figure 6.

FRAGMENTATION TEST

(U) After recovery the projectile was cut into four pieces. The forward end was cut off in the ogive region 5¼" aft of the forward edge of the flat nose plug. A seven-inch long cylindrical section was cut off for explosive loading and fragmentation testing. A ring approximately one inch wide was cut from the remaining portion for metallurgical examination.

(C) Each diamond shaped fragment on the 7" long cylindrical section was scribed as shown in Figure 7. The smooth surface in the figure is the forward bourrelet of the projectile. The ogive region is at the bottom of the figure. There were 160 diamond shaped fragments (20 fragments per circumferential row X 8 rows) in this test specimen. Rows A and M contain only partial diamond fragments.

(C) The 7" cylindrical section was loaded with 4.46 pounds of composition C-3 explosive and detonated in the NWL Fragmentation Chamber for fragment recovery. The blasting cap was located at the end of the cylinder circumscribed by Row A. The recovered fragments were counted and weighed. Photographic results are shown in Figure 8. These fragments represent 99.2% of the total cylinder weight.

(C) The numbered diamond shaped fragments were identified and put on a numbered grid as shown in Figure 9. Note that 100% of the diamond shaped fragments shown in Figure 7 (Rows B through K) were recovered (consideration of Rows A and M as good experimental data was eliminated because the nature of explosive wave propagation in an open-ended cylinder caused unusual stresses in the end regions). Each of these fragments retained their diamond shape and represented excellent fragmentation control. The average weight of the fragments presented in Figure 9 is approximately 400 grains.

(U) The fragments were then re-assembled in a manner similar to a jigsaw puzzle and are shown in Figure 10. Note how well the broken ends fit together.

CONCLUSIONS

(C) The conclusions drawn from this experiment are as follows:

a. An electron beam scored 5"/38 MARK 52 projectile with a heat affected zone penetration depth of 75% wall thickness successfully withstood setback and rotational forces from gun launching at 2285 ft/sec.

b. The 100% control and recovery of 160 diamond shaped fragments in the cylindrical section indicates that the potential of using an electron beam welder to control munition fragmentation is excellent.

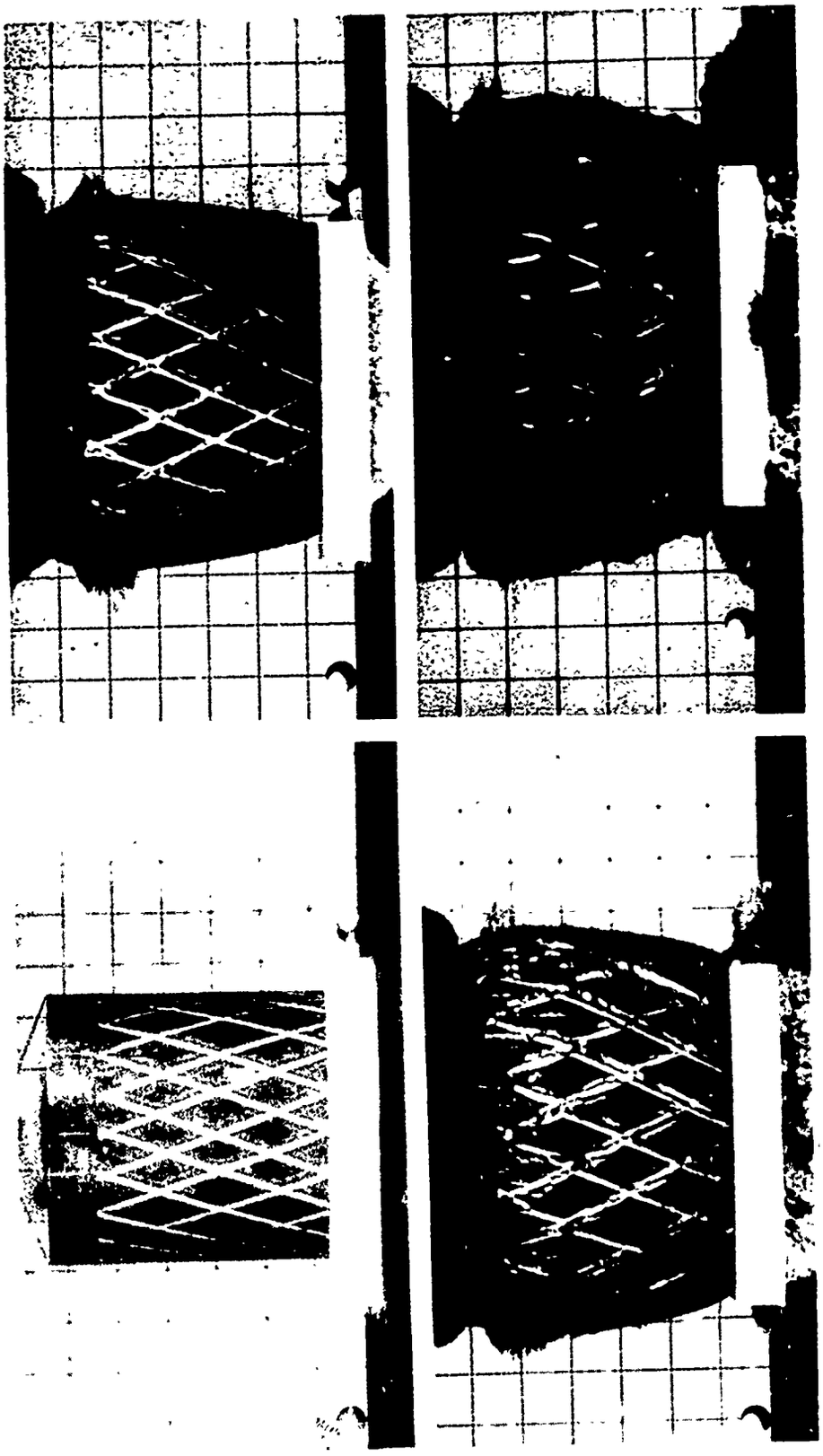
PLANS

(U) Factorial design experiments are presently being conducted on the USMC 155mm projectiles. These studies will investigate such parameters as weld depth, fragment size and weld angle.

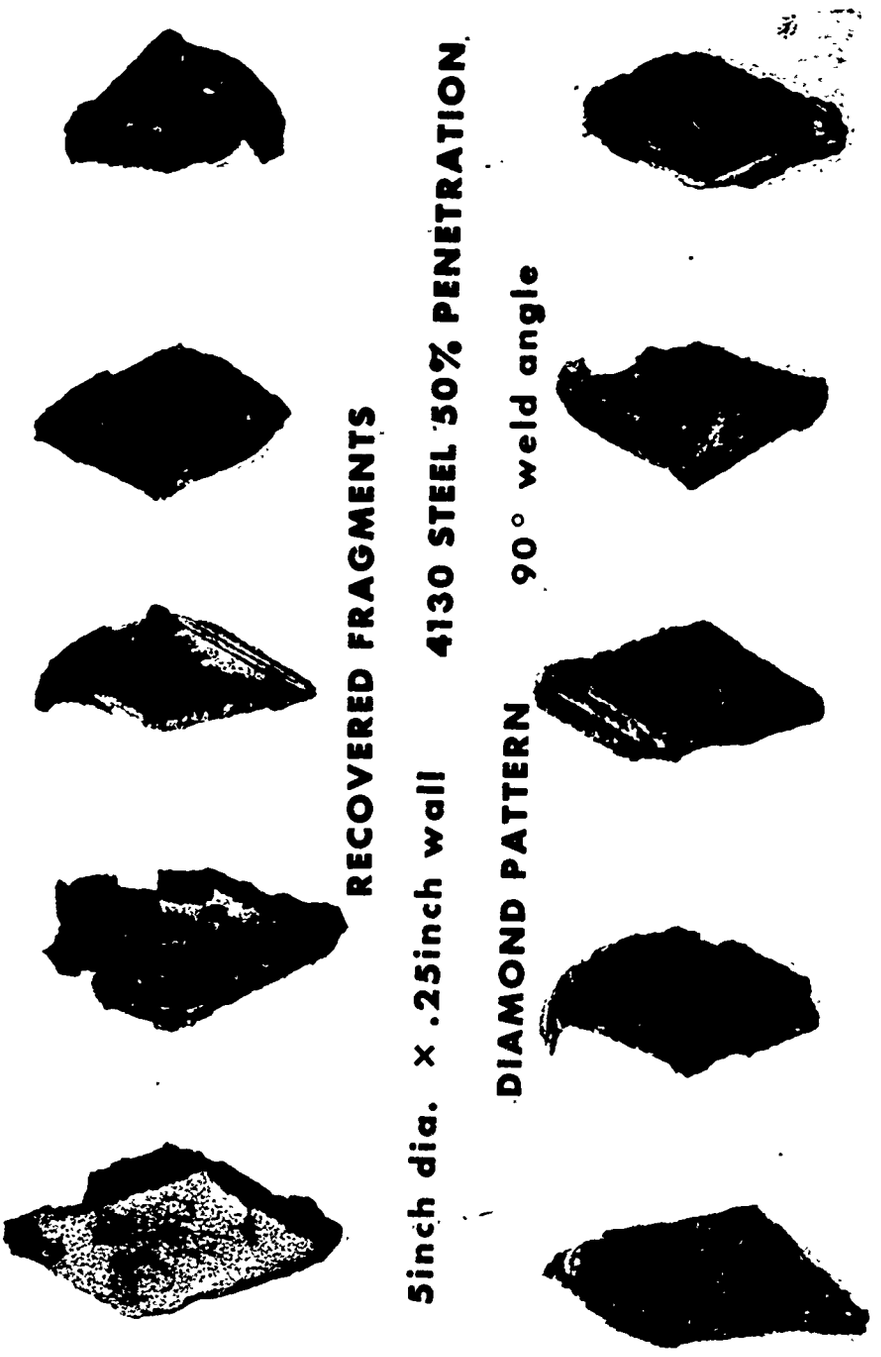
REFERENCES

A. NWL Technical Note TN/G-18/70, *Electron Beam Frag Control* (U). by Raymond J. Polcha, May 1970.

B. NOTS Technical Report 1423, *Controlled Fragmentation of Thin-Walled Metal Cylinders*, by John Pearson and Robert G. S. Sewell, 12 April 1956.

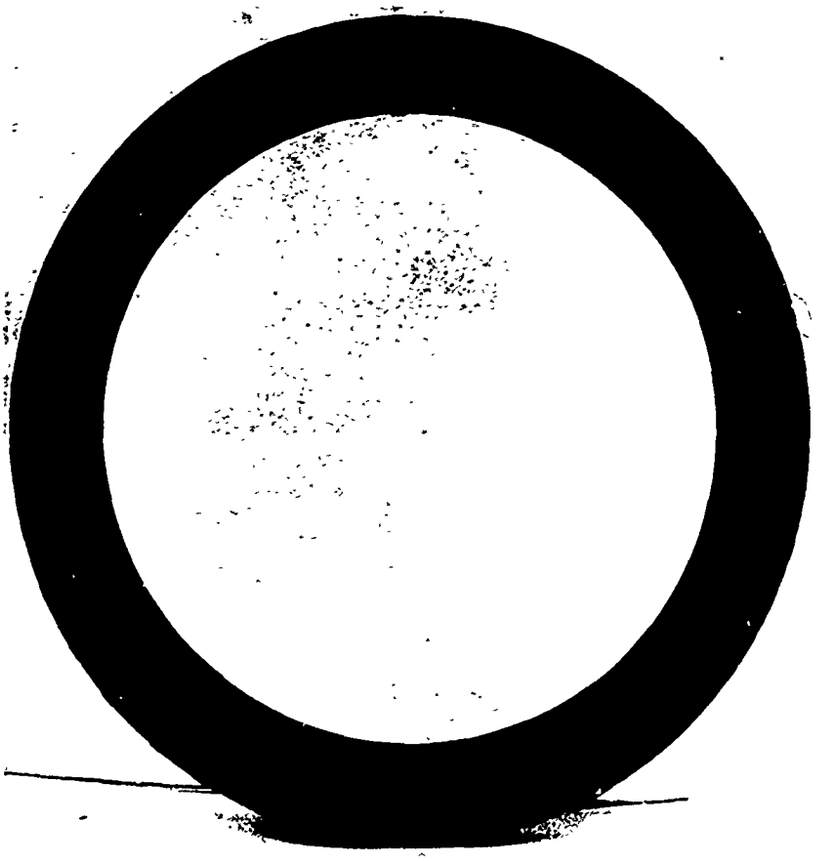


Initial Fragmentation of a 5-Inch Thin-Walled Cylinder (U)
Figure 1



Recovered Fragments from a 5-Inch Thin-Walled Cylinder (U)
Figure 2

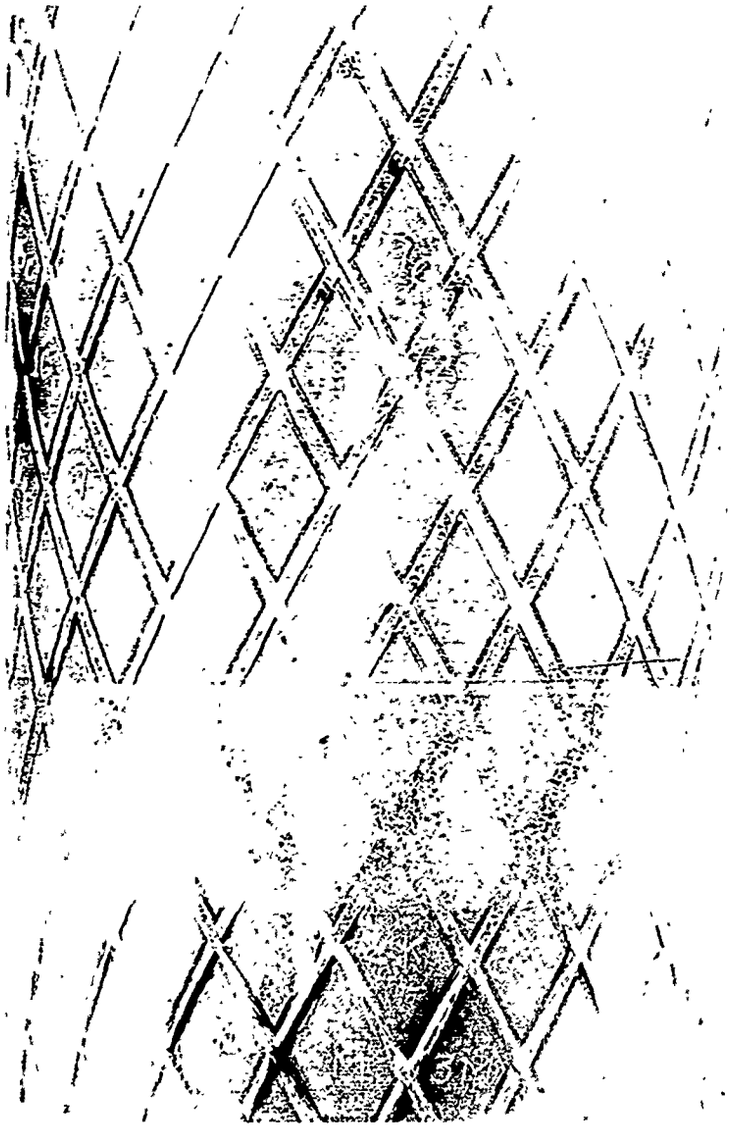
5"/38 Projectile with Diamond Electron Beam Scoring Pattern (U)
Figure 3



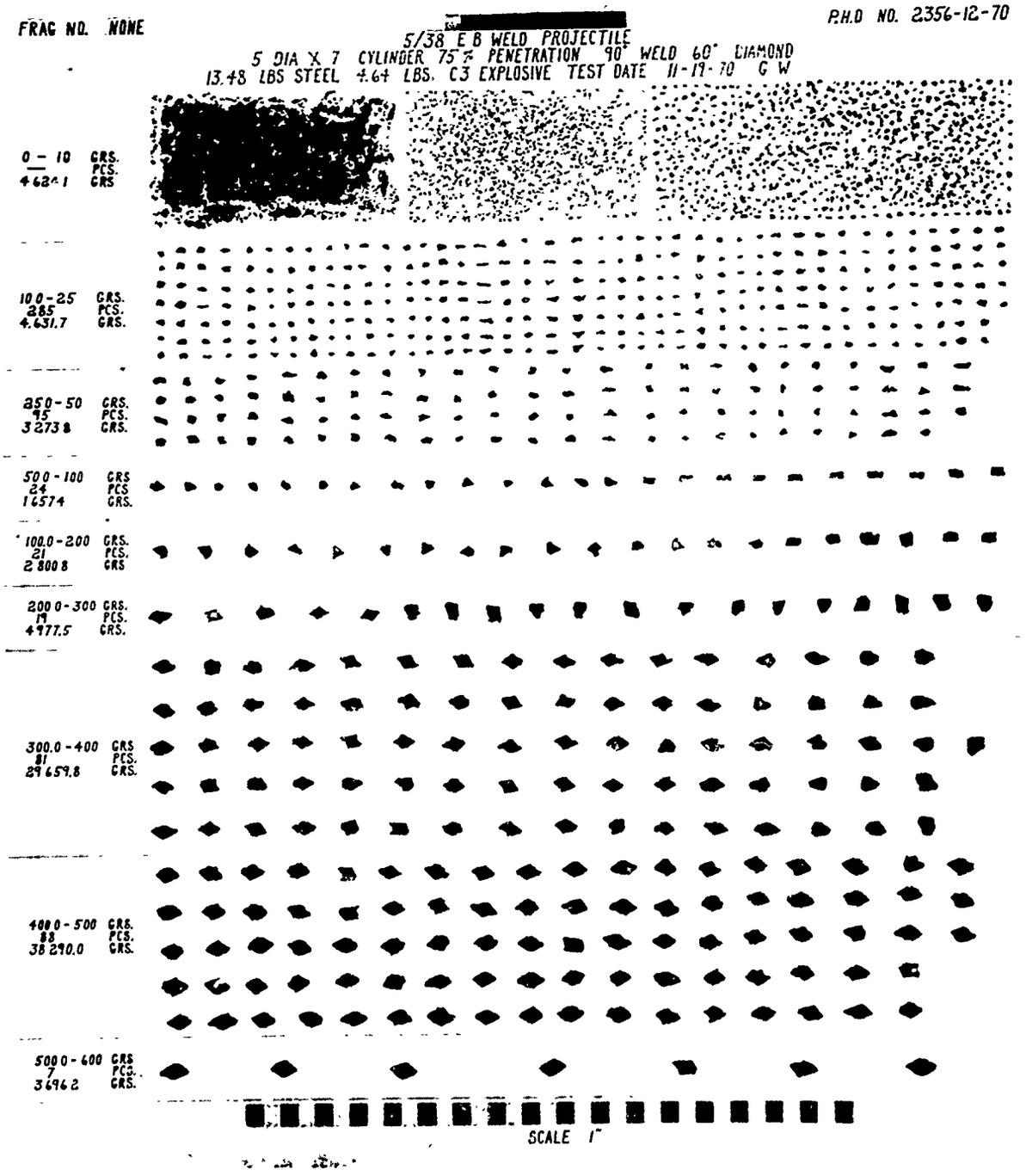
Cross-Section of 5"/38 Projectile's Heat Affected Zones (U)
Figure 4

5"/38 Electron Beam Fragmentation Projectile In Flight (U)
Figure 5

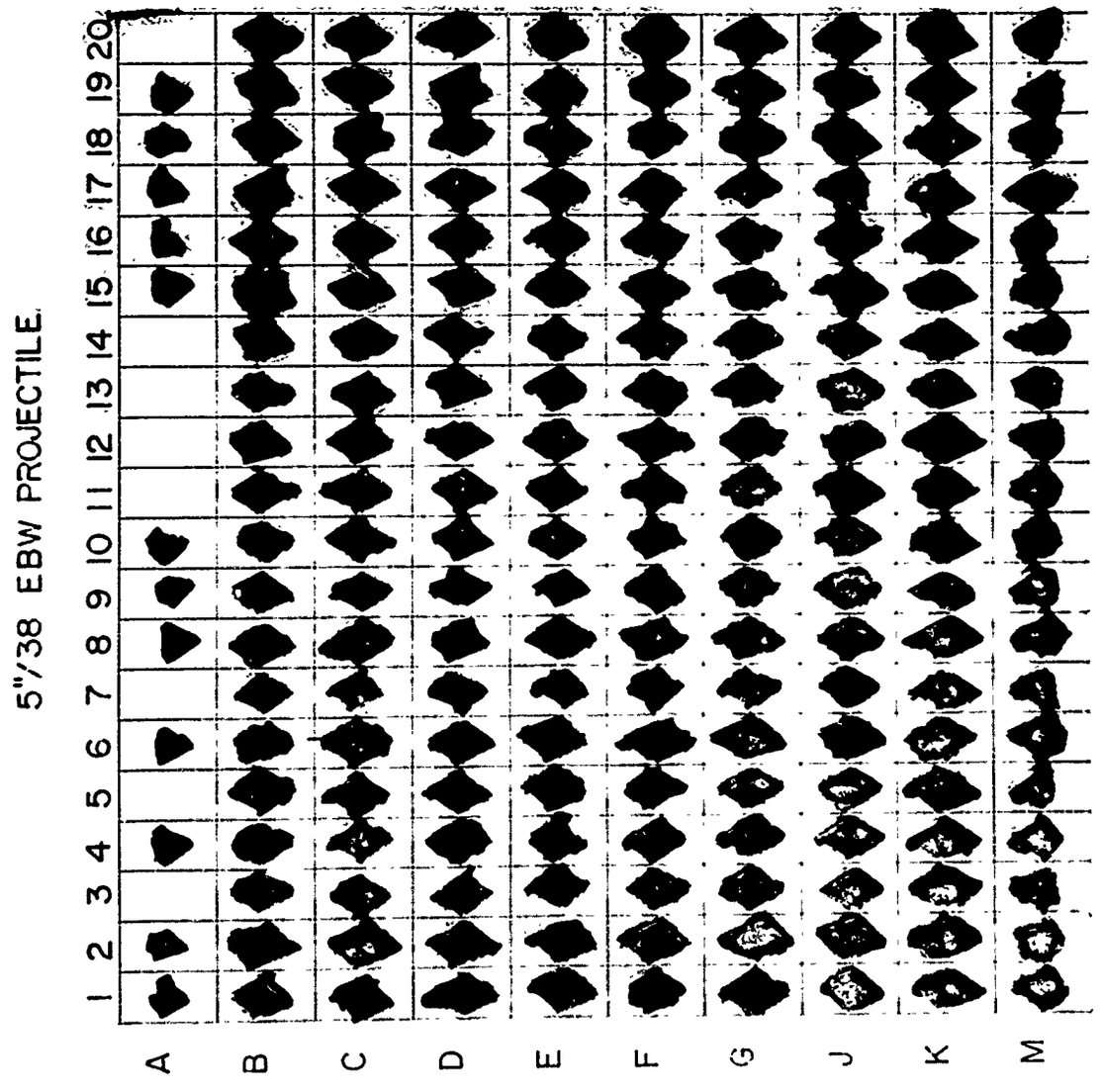
5"/38 Electron Beam Fragmentation Projectile After Gun Firing (U)
Figure 6



Numbering Scheme on the 7″ Cylindrical Test Section (U)
Figure 7



Fragments Recovered from the 7" Cylindrical Section (U)
Figure 8



Recovered Diamond Fragments Located on a Numbered Grid (U)
Figure 9

5"/38 EBW PROJECTILE

Reassembled Metal Cylinder After Fragmentation (U)
Figure 10

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